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ABSTRACT

This discussion of the contributions that cognitive psychology can make to the next generation of instructional design methods begins by comparing behaviorally-based and cognitively-based instructional design systems. Some possible improvements in instructional design are then presented, and it is argued that cognition, or student thought processing, plays a role in learning, and that improvements can occur only when designers actively incorporate findings on information processing into the instructional process. The application of cognitive psychology to the following areas of instructional design is detailed: objectives, kinds of knowledge, learning strategies, evaluation, timing the delivery of components in instructional design, states of knowledge, and criteria for effective evaluation. Finally, the cognitive themes discussed above are incorporated into a simplified instructional design model. The text is supplemented by one figure. (17 references) (EW)

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CHARACTERISTICS OF COGNITIVE INSTRUCTIONAL DESIGN: THE NEXT GENERATION

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CHARACTERISTICS OF COGNITIVE INSTRUCTIONAL DESIGN: THE NEXT GENERATION

This discussion begins with the assumption that cognitive psychology can make significant contributions to the development of the next generation of instructional systems (for simplicity, the term "instructional systems" will be used to define both instructional design theories and models). Much is known about information processing and cognitive science that could be at least considered, if not incorporated, into existing systems to produce more effective systems. A second fundamental assumption to this discussion is that the number of instructional systems currently available serve useful functions in guiding instruction. At present, little change in the macrostructures, or frameworks, of the various systems appears needed. Instead, major change is encouraged in the microstructures of instructional systems — those aspects of instruction which directly affect the learner.

Current trends in educational technology during the last few years have begun to focus on cognitive rather than behavioral aspects of learning (Case & Bereiter, 1984; Gagne', 1987; Gagne' & Dick, 1983; Reigeluth, 1983). In this discussion, several ideas will be presented to reinforce and strengthen this shift in perspective. The primary purpose of this discussion is to present an overview of useful aspects of cognitive psychology which can be immediately implemented by instructional designers. Lastly, a cognitive instructional design will be presented to help current designers incorporate these cognitive principles. This cognitive instructional design is not meant to be added to the large number of existing models, but rather to be used a supplement or adjunct to existing models.

Premises and Assumptions of a Cognitive Approach to Instructional Design

Instructional design, as with other curricular matters, is not simply an all or none matter. It becomes considerably complicated by the purposes to be served by the instruction. For example, different procedures must be followed when instruction is for training relatively simple processes, such as learning of verbal information, as compared to the processes needed in problem-solving.

In many training situations involving simple processes, such as frequently found in lower-level learning, the learning objectives can be <u>closed</u> (prescribed and well-defined). Here learning is algorithmic, that is, there are certain prescribed steps to be followed. Only behavioral statements of goals and performance are required. The primary function of instruction is to guide the learner's intentions and expectations regarding the goal standards. There are certain prescribed steps to be followed and these have but to be acquired and retained until action is taken.

When the instructional goal involves higher-level learning such as comprehension, understanding, decision-making, and problem-solving, then the complexity of instructional practices takes a quantum leap from the requirements of a simple application. The framework of the instructional system might contain many of the same elements involved in guiding lower-level learning, but the implementation at any one stage involves numerous alternatives. There is a need to consider both declarative and procedural knowledge. The objectives are <u>open</u> rather than closed. Open objectives do not have a ready basis for evaluation and may not be easily predetermined. There may be a host of sub-objectives, some of which may correspond to prerequisite knowledge. In addition, the thought processes that students use in instruction interact so complexly with demands, goals, intentions, and expectations that these processes are not easily identifiable. Rather than learning simply to implement a procedure the student must acquire the ability to recognize patterns, to use context in determining course of action, to discriminate among patterns, to generalize, to understand, and to explain what has been learned. To complicate the matter further, the order of events may change from one occasion to another, that is, although there may be an overall desirable sequence, on many occasions recursive rules (to use but one example) may be appropriate.

Instruction involving higher levels of learning should emphasize a debugging process where sources of error provide useful information for implementation of remediation or repair strategies. Some repair is always necessary in comprehension monitoring when the learner detects faulty reasoning patterns, the use of incorrect rules, a poor solution to the problem, lack of understanding, or failure to comprehend a word or text. The instruction needs to consider (or anticipate) what the learner is doing (or might be doing) at each critical decision point. This can be reduced to three main parts: what is the knowledge base of the learner (prior knowledge); what strategy the learner has decided to use to acquire the skill, ability, or knowledge; and whether the strategy is appropriate to achieve the intentions and goals of the instruction. All of these require effective self-monitoring (internal, or learner-driven) which the instruction can prompt (external, or instruction-driven). This is the debugging process and is dependent upon an understanding of the instructional goals. When errors are made they provide important indications of the rules that students are using and permits attempts to correct those rules. This is a somewhat radical difference from the traditionally behavioral approach which simply provides repetitious exercise on that error without considering the rule that is being used (see, for example, Brown & Burton, 1978).

In summary, a cognitive orientation to instructional design is based on several assumptions (see, for example, Neisser, 1976):

1. The past experience of the learner is represented in a highly intricate network of concepts and relationship among them. These networks, or schemata, direct other behaviors of the learner such as perceptions, expectations, strategies, and plans.
2. The perceptual and motor processes select and explore the learning environment for information relevant to the given learning goals and purposes. Thus, the learner is an active processor of information.
3. The information selected modifies the schemata. In turn, the modification affects the later experiences through the processes used and the information to be selected.

As can be seen this cycle emphasizes the activity of the learner. Hence, the current emphasis in the study of learning and information processing on such activities as orienting activities, learning strategies, and comprehension monitoring. These emphases lead to some secondary assumptions (Holley & Dansereau, 1984, p. xv):

1. The activities in which the individual engages (learner-based activities) in academic or technical learning tasks affect the kinds of outcomes achieved.
2. The effectiveness of the learner's activities can be modified or enhanced through instruction, training, evaluation, and remediation.
3. Instructional strategies and activities (instructor-based activities) have their effect through their influence on the learner's cognitive activities.
4. There are currently available learner-based and instructor-based (or text-based) techniques and aids that can be used as vehicles for enhancing the learner's cognitive activities (Weinstein & Mayer, 1985).
5. These activities can be influenced through the use of aids directly incorporated into the delivery of instruction, they can also be influenced through instructing students how to approach given assignments as an integrated part of the curriculum, or they can be taught to learners in separate curricula as general procedures.

A Comparison Between Behaviorally-Based and Cognitive-Based Instructional Design

The purpose of instruction, regardless of perspective, is to positively influence the acquisition of certain, predetermined learning outcomes. It is believed that the instructional means used to obtain the instructional ends can have a dramatic effect on the qualitative aspects of learning, such as how

flexible, durable, and transferable the learning is. It is suggested that the actual determination of the instructional means is dependent largely on which learning perspective, behavorial or cognitive, is taken by the instructional designer. A brief comparison of these perspectives will now be addressed in terms of each perspective's outcome in instructional design.

All designs assume that outcomes depend on an active learner. However, the instructional designer, as cognitivist, might differ from instructional designer as behaviorist in hypotheses about how those activities are engaged in learning. The instructional designer who takes an extreme behavioristic orientation, assumes that the delivery system and definition of the task will wholly determine the learner's activities and should be under complete control of the instructional medium. Note, for example, in the earlier years of programmed learning, the instructional designer spoke of "constructed responses" to refer to cued-responses that had to be supplied by the learner. In addition, such verbs as prompting, fading, and the like assumed learning to be under control of the delivery system. That particular orientation led to ignoring or neglecting what the learner was doing.

The cognitivist, on the other hand, will assume further that the nature of the activity is as important as mere activity. Further the cognitivist assumes that the learner has strategies which may coincide with those expected by the instructor but which may also preempt those the instructor presumes will be used. (Note that the role of learner strategies is not considered within behavioristic orientations). A well-meaning instructor might presume to set as an objective the "meaningful understanding of the subject matter" but simultaneously lectures "from the textbook." The instructor will quickly find that students will follow the textbook and underline those points stressed in the lecture. Rather than develop thinking ability or understanding, the students will fall far short of the goal of meaningful learning because the students' own strategies emphasize the selection of information to be learned in less than meaningful fashion.

Finally, all instructional systems are based, intentionally or not, on the premise that effective time-on-task importantly influences learning. Both the instructional designer and the cognitivist would agree that amount of practice or amount of study is related to degree of learning. Additionally, the cognitivist would be concerned with how the nature of the task would affect the learner's activities (strategies) during the acquisition phase and how these strategies, in turn, would affect the attainment of desired outcomes.

By definition, all designs would be based on the assumption that the aforementioned variables operate interactively. Thus, learning is directly related to the interaction of available and accessible representations of prior learning, the availability and use of strategies by the learner, amount and quality of the time the learner is devotes to the task, the delivery system, and the nature of the evaluation.

A Cognitive Generation of Instructional Design

Some possibilities for improved designs, based on current evidence, will be presented in the subsequent sections of this discussion. The basis for these recommendations rests on recognizing the role played by cognition, or student thought processing, in learning. It is suggested that improvement can only occur when designers actively incorporate findings regarding information-processing into the instructional process. The essential idea is that "research on thought processes examines how instructional presentations influence what students think, believe, and feel and how those thoughts in turn influence achievement" (Clark, 1984, p.2).

The following discussion presents some characteristics of instructional design that are not ordinarily specified in typical descriptions. The points might be considered as a partial listing of criteria by which a given design might be evaluated. Space does not permit an exhaustive and specific enumeration of the specifics of an "ideal" instructional design. Accordingly, only a few examples will be provided.

Objectives

Instructional design models often prescribe the writing of objectives by means of behavioral statements involving stimuli, responses, and performance criteria. Such statements are useful for training situations where performance criteria can be clearly specified. Behavioral objectives provide useful guides for training settings since they help the learner to select relevant information, but left at that point behavioral objectives do not meet the needs of educators concerned with the acquisition of knowledge and thinking skills.

Instructional designers, including curriculum specialists, often neglect the most important of objectives: the objective of achieving comprehension and understanding. Although once an ambiguous construct, there is sufficient literature now existing that can be useful in achieving a definition of understanding, comprehension or thinking. Understanding is an effective objective since it makes provisions for to-be-learned material to be assimilated into the knowledge structure. Such objectives also result in accommodation by a change in the existing structure (that is, a new way of thinking about the material). In the course of such learning, procedural skills that facilitate transfer must also be designated. (From a cognitive view, acquisition of facts is worthless unless there is some provision for teaching the student how the facts can be used).

Failure to attend to the important objective of understanding can be found in many areas of instruction. For example, scientific principles are often learned mechanistically because of the way they are taught. There is a growing body of literature on "misconceptions in science" (see, for example, diSessa, 1982) showing that even when students are familiar with Newton's Laws of Motion they still apply Aristotelian physics to everyday problems that should be solved by the use of Newtonian physics.

Kinds of Knowledge

Although instruction in declarative knowledge (facts, ideas, and so on) should lead to understanding by the learner, instruction in procedural skills (whether part of a perceptual motor skill or of a cognitive skill) should lead to pattern-recognition and action-sequences (operations) that may or may not use declarative knowledge. Generally, in cognate areas, procedural skills are interlaced with declarative knowledge (as, for example, in proving that two triangles are congruent). With expertise, procedural skills become automatic, freeing cognitive resources for higher-level processes. Acquiring automaticity, however, may take thousands of trials (chess players, for example, take thousands of hours of practice before being capable of attaining "master" status). Instruction in both declarative and procedural knowledge, even though well-practiced, may become welded-to-context (can only be used in limited settings such as only to other school subjects) unless the material is presented in a variety of settings and conditions. This provision for decontextualization must be incorporated into the generation of cognitive instructional designs. Most importantly, it seems that an essential goal of education is to produce learners who can learn on their own, to self-generate precise applications when necessary.

Learning Strategies

It is apparent that the desired outcomes of instruction, even when carefully prescribed and delivered, may not always be achieved because of the complex combinations and interaction of influences that exist in instructional settings. What is learned depends, ultimately, on how the student processes the information. Learning and processing strategies will be more efficient if they are used to perform activities in the same way that learners process information, that is, to the extent that the strategy follows its counterparts in the way the mental operations are conducted (Holley & Dansereau, 1984).

Processing is a complicated operation. It depends on the kind of input or nature of the task, what the student knows, what he/she does, amount of quality-time spent on the task, and so on. However, processing is also dependent on the instructor — what the instructor knows about instructional methods, about the subject matter or skill being taught, about the learner, and so on. Even though instructors know much about these matters, there is the influence of what they actually

do. Even though they know a great deal about the subject, the task, and instruction, there is no assurance that they will use such knowledge in the same way as another teacher or that they will use it at all.

Mayer (1984) has presented some examples of teacher-based or text-based aids and their parallels in learner-based strategies. The first level includes aids and strategies designed to help select relevant information from the instruction. Examples of text-based aids at this level include informing the learner of the behavior objectives. The associated learner-based strategy might be underlining or copying. At the next level are aids and strategies for organizing information within the text. Text-based aids here include signalling (e.g., "there are three points to be remembered...", "in summary..." or "the main idea is..."). The parallel learner-based strategy might be structured notetaking, outlining, or concept-mapping. Organizational aids or strategies restricted to the text and used routinely lead to nonmeaningful (verbatim) learning and, thus, only slightly to transfer.

Both selection and organizing are prerequisites for integrating information into the cognitive structure (integration being a necessary condition for meaningful learning). Text-based aids include advance organizers or summaries placed at the beginning of a chapter. Learner-based strategies include the making of elaborations or inferences. These extend the information in the text by adding information that the learner already knows. The use of continuity (making cause-effect relations), adding details, or using analogies and metaphors can be either text-based or learner-based and are other means of linking new information to the cognitive structure of the learner. Material that is integrated, and thereby made meaningful, has the advantage of not only being retained and retrieved more effectively than partially meaningful learning but is also more easily transferred to other learning situations.

Evaluation

The interaction of teacher and student knowledge and activities influences the learning processes, but the outcomes of the process may not be tapped or may be misleading if inappropriate evaluation measures are employed. Whether teacher-made or standardized, the tests used in many instructional settings (outside of training settings) often measure different kinds of outcomes than intended. Such variation may occur at different levels. For example, reading tests are intended to measure comprehension of a passage (text-dependent comprehension), yet may measure what the reader knows rather than what he or she got out of a passage (text-independent tests). Test items selected only on the basis of their statistical characteristics may be found to depend on different processes (e.g., immediate recall of a fact or idea) than those taught or may measure different outcomes than those stated in the objectives. The designer must be concerned with whether items are measuring factual information, conceptual information, problem-solving ability, or transferability. Too often so-called achievement tests measure only the verbatim acquisition of factual information when the desired outcome is the ability to use that information in a transfer situation.

The kind of test administered also interacts with teacher/student variables. Teachers who do not emphasize understanding or who may be under a great deal of extra-school pressure (community, political, and so on) may, for one reason or another, resort to common use of some familiar form of measurement such as multiple-choice tests that tend to establish student expectations about how their performance is to be examined. These expectations influence the way the material is processed; students study for multiple-choice tests differently (perhaps only for recognition) than they do for essay tests (which may require them to study for integration of information), for example.

Timing the Delivery of Components in Instructional Design

In a similar vein, training of teachers in instructional design, or of any instructional procedure, does not necessarily provide assurance that they will use that training. Similarly, timing in the use of a given component of the design is often neglected in instructional designs. Timing of practice or exercises may make a difference in ease of learning. Thus, expert teachers use practice exercises after a unit has been completed, whereas novices assign practice exercises after an "arbitrarily" determined time period, such as the end of a class period, whether or not the student has the necessary skills for

conducting the exercises with competence.

States of Knowledge

A frequently overlooked concern in instructional design is how the information in the relatively new investigations of experts versus novices is to be used. There is a vast amount of literature on this topic from a number of sources, ranging from descriptions of the way experts and novices play chess, to what experts recall from the narration of a baseball game, and to the way experts and novices conceptualize physics problems. These studies imply that knowledge in the first stages of learning does not have the same structure as knowledge at later stages of learning. Another premise is that cognitive processes vary with the stages of learning (for example, the selection of superficial features attended to by novices and the selection of fundamentally more sophisticated patterns attended to by experts).

An elementary form of a theory of states of knowledge might be patterned after Rumelhart and Norman's (1978) description of the phases of learning. Their framework is interesting because it conceptualizes learning over the long haul in terms of three phases: accretion, restructuring, and tuning. These phases correspond to early, middle, and later stages of learning resulting in different states of knowledge at each.

Each state implies different methods of teaching, studying, and testing. In the accretion stage new information is delivered in a form that links a new idea with the student's knowledge structure and results in the assimilation of that information. The method of testing is in the form of typical multiple-choice or short-answer tests. Since the knowledge is likely to be stored in relatively isolated form there is high probability of interference from related topics. Transferability in this phase is nil. In the second, restructuring, phase the information already acquired is put into different organizational patterns through such means as the inquiry technique, the discovery method, or the Socratic Dialogue. Interference from related topics is medium. Transferability is high. Appropriate evaluation measures here would be the ability to apply knowledge to new situations and the ability to conceptualize information. In the final, tuning, stage the use of the knowledge (both declarative and procedural) is made efficient through refinement of discriminations, patterns, and skills. Practice under varying conditions is an important teaching device here since new information and skills are not learned, only refined. There is low probability of interference from related information since the information is well-specified and contextually related. Transfer of general information is high, but transfer of specific information is low (because there has been a well developed system of patterns). However, the specific information can be derived from the general information. The appropriate tests for this level of acquisition would be testing under stress, precision in the use of a knowledge or skill, the ability to use deep explanations of classifications, and the ability to use the information in problem solving.

One should note that were we to examine our current instructional practices objectively and closely, we would find that most instruction stops at the accretion phase. Although many, perhaps most, students do ultimately achieve higher states of knowledge, it is because of the tendency of human learners to reconstruct and otherwise organize what they have learned and not because of the deliberate attempts of their instructors or of their textbooks.

Criteria for Effective Instruction

Whatever the instructional design employed and whether the outcome is strategy or knowledge, the desired learning outcome, if achieved, should meet several criteria, most of which are either neglected or ignored in both typical instructional and research settings. These criteria include the following:

1. The achievement should be flexible. The learner should be capable of using the knowledge in at least the variety of settings in which it will be used frequently.
2. The achievement should be durable. Learning the material sufficiently well to "pass" an immediate test is not acceptable. Most information or skills learned will not be

used immediately. Rather, they will be used in a subsequent course, on the job a few months later, or even years later when retraining may be required.

3. The achievement should be transferable. There are minimum requirements here. One, for example, should be able to use "writing a check" procedure for money orders as well. More demanding requirements would be required to employ the principle of refraction to solve problems involving lenses, prisms, rainbows, distortions in visual images when a pencil is placed half way into a glass of water, or "mirages" one may see when traveling over a hot desert road.
4. The use of strategies and knowledge should be self-regulated. This simply means that they can be used on demand by the learner and can be used appropriately for a given situation without the necessity of being cued by an external source such as an instructor ("now use this rule for solving the problem").

Cognitive Affective Considerations

The discussion above has focussed on the acquisition of knowledge and skills, sometimes described as the "cold" side of learning. There is underlying all of this, however, an acknowledgment of the influence of the affective variables (see, for example, Lepper, 1985). Their influence is most readily seen in the concepts of "motivation" and "feedback". Due to their complexity, perhaps, they rarely are employed formally in instructional systems designs. Rather, affective variables often are merely cited as important or described superficially, in descriptions of motivation and feedback as some of the "events of instruction".

Motivation includes both affective and cognitive components. Such motivations may be in the form of motives, intentions and expectations, attributions, anxieties, reward, avoidance of aversive stimulation, informative feedback, acceptance of a model's behavior in social imitation, environmental influences (such as encouragement in the home for reading), or attitudes. There is no doubt that the affective components of learning need to be incorporated into instructional design not only from the point of view of the instructional designer, but from the point of view of the cognitivist as well. But the important role of affective variables, as a consideration in instructional design, is another topic to be developed in the future.

Summary

This section presented many examples of how student thought processing ultimately influences achievement. These views were presented in contrast to the traditionally behavioral orientation which systematically ignores the importance of cognitive processing. The cognitive orientation brings student thought processing to center stage. The cognitive orientation to instructional design is summed up by Clark (1984): "The distinctive characteristic of cognitive research is the idea that instruction influences achievement through student thought processes. That is, instruction influences thinking and in turn thinking influences learning and performance. The cognitive approach therefore assumes that instruction is mediated by student thought processes" (p. 2).

A Cognitively Engineered Instructional Design

In order to serve as an organized conclusion to this discussion, as well as to synthesize the thoughts and ideas expressed, this last section will present a simplified instructional design model which incorporates a cognitive theme. The term "cognitively engineered design" is used to refer to the instruction/delivery systems/learner interface which entails the process of giving learners experiences and training that help them to use and understand the cognitive skills most appropriate for a given learning task and to use the most efficient media for accomplishing the task. This is a slight departure from its use by Norman (1980; 1986) to refer to the science of designing man-machine interfaces, a currently popular theme in design problems raised by the microcomputer revolution. The term "cognitively engineered instruction" applies the increasing knowledge of human cognition to

the advances in technology and media as represented in the model displayed in Figure 1.

Insert Figure 1 About Here

This model has the three main parts common to all instructional design models: pre-instructional activities; delivery (or administration) of instruction; and evaluation of learning outcomes as integral parts of an instructional episode. A key difference from traditional design is that design decisions are based on conceptualizations of human cognition and the learner as active rather than passive. As previously discussed, a cognitive orientation allows the instructional designer to make lesson decisions based on how learning, understanding and memory occur rather than via the traditional behavioral position of manipulating input without consideration of the effect of internal events on outcomes. An advantage of a cognitive model is that it brings to awareness important insights into situations where learning does not occur as planned and provides means of revising the design. Both behavioral and cognitive positions provide "ammunition" in the struggle to help facilitate learning, but the cognitive approach provides more information about "where to aim".

Initially, two activities must take place before the instruction can be delivered. The learner's cognitive state needs to be identified while the learning outcomes of the instructional task are defined. For example, if the instructional task is to consider what events led the North to victory in the Civil War, then a great many facts need to be considered quickly and efficiently. A student who is at the accretion stage (and thus is just beginning to acquire the necessary facts about the Civil War) would obviously be unable to handle the problem solving task presented. Hence, the states of the learner and of the instruction are incompatible and mismatched. It would be fruitless to require the learner to proceed with the task and continuing to do so would only lead to frustration for both learner and teacher. By the same token, a learner at the tuning stage has all of the important facts and concepts about the Civil War selected and organized. Activities which continue to review the same facts would prove very tedious and boring. Such learners require experiences which foster accessing and applying that learned information in new and creative ways. For efficient and effective learning to occur, the learner's cognitive state and the learning outcome of the instruction desired should match.

Once the learner's cognitive state and the learning outcome are perceived as compatible, the designers must ensure that the activities and learning experiences presented foster the desired outcome. This second stage in planning the delivery of instruction requires that cognitive processes corresponding to the state of the learner's knowledge (e.g., accretion, restructuring, or tuning) are activated. For example, typical teaching techniques such as the use of mnemonic aids and rehearsal strategies might work well for the accretion stage where the learner is in the process of selecting relevant information for acquisition and storage preparatory to organizing it. But these same activities are relatively poor for higher order processing that would be required as the learner further organizes, integrates, and chunks information into useful schematic knowledge representations. Instead, learning activities might include analogical reasoning, metaphoric representations, elaboration, summarization, identifying cause-effect relations, or spatial mapping. A learner at the tuning stage would benefit from activities that would foster additional elaboration of the lesson material, ability to make applications to a variety of everyday situations or to achieve automaticity in pattern recognition, the use of procedural knowledge, retrievability and so on. Different instructional activities foster (activate) different cognitive processes. Appropriate cognitive processing needs instructional activities geared to achieve the use of specific processes.

Even with these precautions, standardized learning outcomes for all students can never be guaranteed due to the many factors which enter and complicate the instructional setting. Proper evaluation of the type of learning expected can be very difficult especially when this learning is beyond the accretion stage. It would probably be rather difficult (though not impossible) for an

instructional designer to construct multiple-choice questions which test students at the restructuring or tuning stage. A variety of testing situations would be necessary to derive an accurate picture of these types of learning. An example of such a testing technique would be to give the student a story without an ending and ask for plausible predictions. As in most instructional design models, if the designated criterial level has not been attained a decision must be made whether to provide the learner with remedial activities such as different strategies or techniques for comprehension monitoring or whether some revision of the instructional level of the curriculum is necessary to adapt to the learners cognitive state or level of knowledge representation and then have the learner recycle through a portion of the program. The remediation box displayed in Figure 1 requires the same considerations regarding processing demands as any other part of the design.

Lastly, it must be remembered that this model has been greatly oversimplified to make the dialogue readable. For example, it is widely recognized that the three cognitive stages discussed (accretion, restructuring, tuning) are not mutually exclusive. A learner is almost certainly interacting with the instructional material at all levels to some extent. The intention of painting this "cognitive picture" of the instructional design process has been to set the stage for understanding the advantages of considering instructional design from a cognitive orientation. Future developments in instructional design should reflect this cognitive view.

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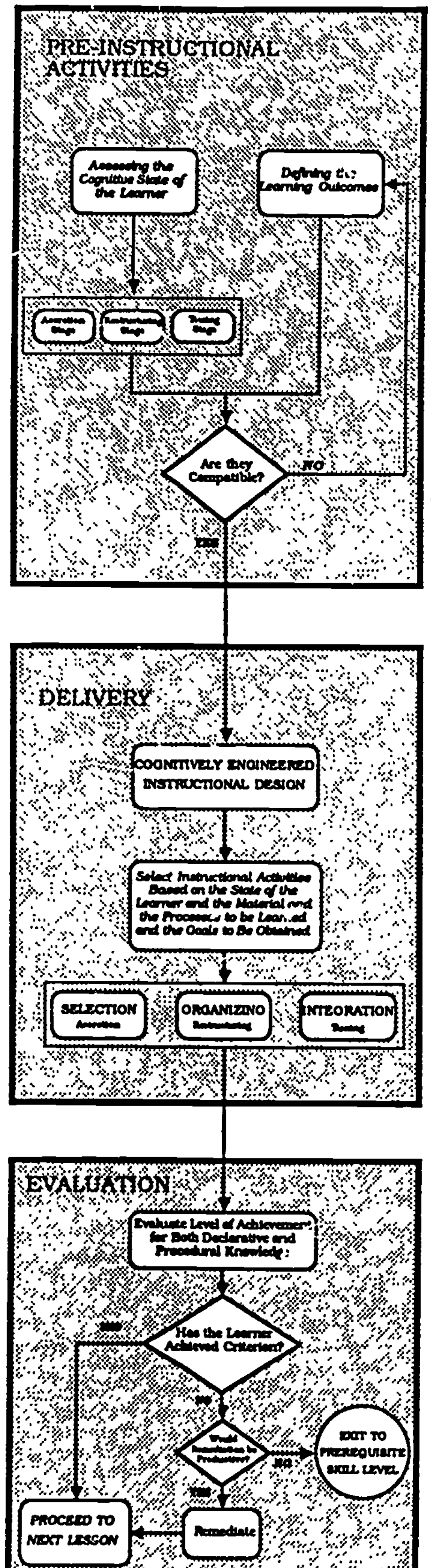

Figure 1. A "Cognitively Engineered" Instructional De[illegible] Model